   

40 YEARS OF RESEARCH ON NITROGEN

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“Coupling C - N - P - S cycles”

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N_2O SOIL EMISSIONS AFTER BIOCHAR AMENDMENT: CONTRASTING RESPONSES DEPENDING ON THE ORIGINAL FEEDSTOCK

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INTRODUCTION

It has been demonstrated that biochar addition to soils reduces N_2O emissions in most cases (Cayuela et al., 2014) In this sense, molar O/C and H/C ratios are considered useful indicators to evaluate biochar recalcitrance and its potential in reducing GHG emissions (Spokas, 2010; Cayuela et al., 2015). Nevertheless, biochar properties depend on their feedstocks as well as on the pyrolysis conditions such as heating rate, highest pyrolysis temperature or residence time (Downie, 2011). Thus, generalizations about biochar GHG mitigation potential remain elusive due to the high heterogeneity of biochar properties and reactivity in soils.

In an effort to elucidate how biochars made from different feedstocks would affect N_2O release from agricultural soils, laboratory soil incubations in optimum conditions for denitrification were conducted. Eleven residues from the agricultural and agro-industrial sector widely available in the Mediterranean area were selected as feedstocks.

MATERIAL AND METHODS

Soil and biochar characterization

A fine texture silty clay agricultural soil (Calcic xerosol, USDA classification) was selected to perform the experiments. It was collected from a grapevine cultivated land located in Totana (Murcia, coordinates: 37˚ 47' N, 1˚ 34' W), air dried and sieved below 2 mm. The soil pH was 8.7 and EC 177 µS cm^{-1} (water extract, 1:20 w:w 25˚C). Biochars were obtained from pyrolysis of eleven different feedstocks at 600˚C with a residence time of 2 h. Feedstocks were obtained from crop residues (primary feedstocks) and from agro-wastes derived from the subsequent agro-industrial processing (secondary feedstocks). Biochar main characteristics are shown in Table 1.

Table 1. Chemical characterization of the biochars

	AP	OlvP	CP	GP	OP	TPOMW	GS	GR	RS	TC	TC+S
pH*	12.3	11.1	10.3	10.4	11.5	12.1	10.7	10.3	10.2	12.1	12.4
EC* (mS cm^{-1})	3.32	754×10^{-3}	1.45	3.23	6.33	7.75	4.52	3.13	4.43	22.8	10.07
H/C**	0.24	0.23	0.28	0.44	0.26	0.32	0.28	0.29	0.29	0.37	0.30
O/C**	0.08	0.07	0.08	0.09	0.10	0.07	0.09	0.10	0.12	0.28	0.11

AP: Almond Tree Pruning; OlvP: Olive Tree Pruning; CP: Carob Tree Pruning; GP: Grapevine Pruning; OP: Orange Tree Pruning; TPOMW: Two Phase Olive Mill Waste; GS: Grape Stalks; GR: Giant Reed; RS: Rice straw; TC: Tomato Crop; TC+S: Tomato Crop with substrate (peat). * Water extract 1:20 w:w 25˚C*. ** molar ratio

Soil incubations

Soil incubations were performed in 250 ml polypropylene jars at 25˚C and 90% of the water filled pore space (WFPS) and lasted 28 days. The control treatment consisted of 100 g of dry soil and the treatments with biochar contained 98 g of dry soil and 2 g of dry biochar. Moisture content was adjusted adding a solution of KNO_3 in order to apply an equivalent rate of 200 kg N ha^{-1} (corresponding to 66 mg N kg^{-1} based on a plough layer of 25 cm). The jars were incubated aerobically, covered with a wet cloth which allowed gas exchange and minimized evaporation. N_2O samples were taken twice a day during the two first days decreasing subsequently to daily measurements during the first two weeks, then every 3-4 days during the third week and a week after at the end of the incubation. Four replicates of each treatment were stablished.

RESULTS AND DISCUSSION

N2O emissions were very low (average N2O flux ratio from 1.74 to 30.83 µg h-1 kg-1, depending on the treatment) despite the NO3- input in all treatments. However, there was a contrasting response to biochar addition depending on its feedstock. All the pruning derived biochars (AP, OlvP, CP, GP and OP) had low H/C and O/C molar ratios and, as it was expected, N2O release was lower when this type of biochar was added to the soil. However, this consistent result was not found with the rest of biochars derived from herbaceous and secondary wastes. In the latest, N2O-N cumulative emissions ranged from a 46.61% decrease in TC treatment to a 702.63% increase in the case of RS addition.

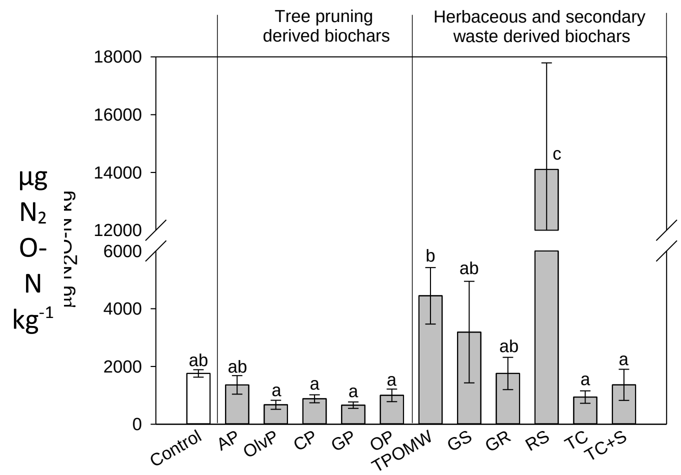

Figure 1. Soil cumulative N_2O-N emissions. Error bars indicate standard deviation (n=4). Letters indicate significant differences between treatments according to Tukey's method (α=0.05). AP: Almond Tree Pruning; OlvP: Olive Tree Pruning; CP: Carob Tree Pruning; GP: Grapevine Pruning; OP: Orange Tree Pruning; TPOMW: Two Phase Olive Mill Waste; GS: Grape Stalks; GR: Giant Reed; RS: Rice straw; TC: Tomato Crop; TC+S: Tomato Crop with substrate (peat).

CONCLUSION

Consistently with previous results found in the scientific literature, biochars obtained from the pyrolysis of tree pruning at 600˚C mitigated N_2O-N emissions from this soil. However, biochars obtained from other feedstocks had a contrasting impact on N_2O emissions being their H/C and O/C molar ratios of no value in predicting their mitigation potential. Our results indicate that adequate indicators of biochar capacity in reducing N_2O emissions remain hard to define when feedstock sources are different to those derived from tree pruning.

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